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Soil Moisture Survey

of some representative
Minnesota soils

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Prepared by

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Agricultural Research Service

and

Soil Conservation Service
U. S. Department of Agriculture

and

Minnesota Agricultural Experiment Station

Cooperating

SOIL MOISTURE SURVEY OF SOME REPRESENTATIVE MINNESOTA SOILS¹

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INTRODUCTION

Minnesota lies in the subhumid climatic zone. This fact emphasizes the need of evaluating soil moisture characteristics of the major agricultural soils of the State. In most years there are areas in the State where crops suffer from lack of moisture. Soils most likely to run short of water are those whose retentive capacity for moisture is low (especially sandy soils). However, in an extended period of below normal rainfall, drought conditions are experienced on soils regardless of their water storage capacity.

As an aid to understanding soil moisture conservation needs in Minnesota, a survey of the water holding characteristics of some major soil types has been undertaken.

AREA OF INVESTIGATION

Soils selected for survey have to date been restricted primarily to the western edge of the State but include some soils in the south-central and southeastern portions (Fig. 1).

The soils chosen for investigation represent the Chernozem, Prairie, Degraded Chernozem, Gray-Brown Podzolic, and Humic Gley great soil groups. An attempt was made to choose soils representative of rather broad areas so as to make the information obtained applicable to as large an area as possible.

The soils have been largely selected from farms operated by Soil Conservation District cooperators and consequently represent a high level of soil management.

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A total of nineteen soils has been studied. Table 1 lists these soils according to sample number, soil type, location, soil group, and total and available inches of water to 5 feet.

Soil profile descriptions for each soil investigated, together with moisture release data, particle size distribution, bulk density and total and available inches of water, appear in tabular form at the end of this introductory text.

EXPERIMENTAL MEASUREMENTS

In order to express soil moisture on a volume basis (i.e. inches of water per inch or per foot of soil), it is necessary to know both the percent of water on a dry weight basis and the bulk density of the soil. With this information the calculation to inches of water becomes

$$\text{Inches of water} = \frac{\text{Bulk density}}{\text{Density of water}} \times \text{depth of soil} \times \text{percent moisture (dry weight basis)}$$

DETERMINATION OF BULK DENSITY

Bulk density refers to the oven dry mass (i.e. weight) of a known volume of soil as it exists in place in the field and is expressed as weight per unit volume (i.e. grams per cubic centimeter).

The procedure used in determining the bulk density values reported in this paper has been to obtain undisturbed core samples of a known volume with the use of a core sampler. The cores are dried in the oven and weighed, then the weight per unit volume calculated. Bulk densities for each horizon of each soil were determined at least in duplicate. These values were used to convert the soil moisture from percent by weight to a percent by volume basis.

MOISTURE DATA

In order to arrive at an estimation of the amount of water in the soil that is available for plants to use, we must evaluate the upper (wetter) and lower (drier) limits for each soil and for each horizon within each soil. A laboratory method was used to estimate the amount of moisture held by a soil when it had been completely recharged with water to its field capacity and also when it was so dry that plants wilted. To do this a pressure is applied to moisture in a wet soil sample to approximate water removal under field conditions. The pressure selected for removing water to measure field capacity, the upper available moisture limit, was 1/3 atmosphere, or about 5 pounds per square inch. On coarse-textured horizons, field capacity is better estimated by a 1/10-atmosphere pressure; figures for this pressure were determined for each soil horizon. The 1/3-atmosphere value may overestimate field capacity for fine-textured soils, but its ease of determination as compared with field

determination seems to justify its use. The lower limit of available moisture, or wilting point, is estimated by applying a 15-atmosphere pressure differential, or about 220 pounds per square inch.

In addition to evaluating available moisture limits ($1/3$ - and 15-atmosphere percentages) for each of the soil horizons, a complete moisture release curve was determined. This gives values of soil moisture on a percent dry weight basis for each of the horizons of all the soils at $1/10$, $1/3$, $2/3$, 1, 2, 5, 10, and 15 atmospheres.

Knowing the upper and lower soil moisture storage limits for a soil, or horizon within a soil, we are able to define its available moisture and express it in terms of the number of inches that can be stored and made available to a crop grown on that soil. Thus, with a knowledge of the number of inches of water needed to produce a crop and an estimation of the inches of water available in the soil at planting time, a better estimation of moisture needs can be made.

PARTICLE SIZE DISTRIBUTION

The particle size distribution was estimated for each horizon of each soil by the hydrometer method. Forty-second and two-hour readings were made to estimate the sand, silt, and clay fractions. Clay fractions were more precisely determined on a few of the soils by the Day method.³ These results indicate that the usual hydrometer method overestimated the 2μ clay by about 3 to 5 percent on these soils.

³ Day, P. R. Report of the Committee on Physical Analyses, 1954-55, Soil Science Society of America. Soil Sci. Soc. Amer. Proc 20: 167-169. 1956.

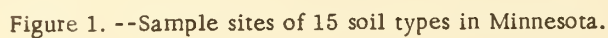


TABLE 1.--Total water holding capacity and available water in Minnesota soils

Sample No.	Soil Type	County	Great Soil Group	Total Inches of Water to 5 Feet	Available Inches of Water to 5 Feet
1.	Aastad silty clay loam	Chippewa	Chernozem	23.99	13.63
2.	Aastad clay loam	Lyon	Chernozem	22.30	12.15
3.	Barnes loam	Otter Tail	Chernozem	23.22	12.47
4.	Barnes clay loam	Chippewa	Chernozem	24.46	12.72
5.	Barnes clay loam	Lyon	Chernozem	21.52	11.46
6.	Bearden silt loam	Wilkin	Chernozem	25.30	13.65
7.	Dickinson sandy loam	Redwood	Prairie	7.30	3.94
8.	Fargo silty clay	Wilkin	Humic Gley	31.28	13.37
9.	Fayette silt loam	Wabasha	Gray-Brown Podzolic	22.99	14.37
10.	Kranzburg silt loam	Pipestone	Chernozem	24.34	13.93
11.	Moody silt loam	Rock	Chernozem	22.33	13.30
12.	Mora silt loam	Mille Lacs	Gray-Brown Podzolic	13.38	9.06
13.	Nicollet clay loam	Sibley	Prairie	22.39	10.84
14.	Nicollet clay loam	Watonwan	Prairie	21.42	11.86
15.	Rothsay silt loam	Lac qui Parle	Chernozem	19.57	12.29
16.	Rothsay silt loam	Lac qui Parle	Chernozem	19.02	10.66
17.	Vienna silty clay loam	Nobles	Chernozem	22.46	12.28
18.	Waukon silt loam	Otter Tail	Degraded Chernozem	21.68	11.07
19.	Waukon clay loam	Otter tail	Degraded Chernozem	17.64	9.74

SOIL PROFILE DESCRIPTIONSample 1*

Soil Type: Aastad Silty Clay Loam

Location: Chippewa County, SE 1/4 of NW 1/4, Section 4, Granite Falls Tp.,
T.116N, R.39W

Parent Material: Glacial till

Classification: Chernozem

Relief: Nearly level

Drainage: Moderately well drained

Slope: 2 percent

Horizon	Depth	Description
A _p	0"-7"	Black (10YR 2/1) silty clay loam; massive structure; friable when moist; pH 6.5
A ₁	7"-13"	Black (10YR 2/1) silty clay loam; medium weak subangular blocky structure; friable when moist; pH 6.5
B ₂₁	13"-18"	Very dark grayish brown (2.5Y 3/2) silty clay loam; fine weak subangular blocky structure; friable when moist; pH 7.0
B ₂₂	18"-24"	Olive brown (2.5Y 4/4) silty clay loam; fine weak subangular blocky structure; friable when moist; slight effervescence; pH 7.4
C ₂₁	24"-33"	Light olive brown (2.5Y 5/4) clay loam; structureless; friable when moist; strong effervescence
C _{ca}	33"-40"	Light olive brown (2.5Y 5/4) clay loam; structureless; friable when moist; calcium concretions present; violent effervescence
C ₂₃	40"+	Light olive brown (2.5Y 5/4) clay loam; structureless; strong effervescence

NOTE: Colors given for moist soil

*Locations of samplings are denoted by sample numbers on figure 1.

Aastad Silty Clay Loam
Chippewa County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-7	37.4	26.3	23.0	20.8	18.0	16.1	12.8	11.8	11.1
7-13	41.0	28.4	24.6	22.2	19.2	16.6	13.2	12.4	11.4
13-18	40.0	28.2	23.4	21.6	18.5	16.0	12.3	11.4	11.2
18-24	31.6	25.7	23.3	21.8	18.4	17.8	14.8	13.6	12.5
24-33	34.1	27.4	25.2	23.7	20.3	19.4	15.4	13.2	12.0
36-48	34.1	28.1	26.0	24.7	20.7	20.3	15.8	13.2	12.1
48-60	31.9	26.7	24.8	23.5	21.0	19.0	15.2	12.7	11.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-7	1.10	37.4	36.0	26.6	0.17	1.19	2.03
7-13	1.16	30.5	40.9	28.6	.20	1.20	1.98
13-18	1.29	23.5	40.8	35.7	.22	1.10	1.80
18-24	1.43	34.0	27.3	38.7	.19	1.14	2.22
24-33	1.57	31.8	29.7	38.5	.24	2.88	5.16
36-48	1.58	55.3	22.4	22.3	.26	3.12	5.42
48-60	1.63	41.8	28.5	29.7	.25	<u>3.00</u>	<u>5.28</u>

Total in a 5-foot profile... 13.63 23.99

SOIL PROFILE DESCRIPTIONSample 2

Soil Type: Aastad Clay loam

Location: Lyon County, center of NE 1/4 of SE 1/4, Section 24, T.109N, R.40W

Parent Material: Calcareous Mankato-Cary glacial till

Classification: Chernozem

Drainage: Moderately well drained

Relief: Slightly convex

Slope: 1 percent

Horizon	Depth	Description
A _{1p}	0"-8"	Black (10YR 2/1) clay loam; massive structure; friable when moist; pH 6.1
A ₁₂	8"-14"	Black (10YR 2/1) clay loam; weak to moderately developed fine and very fine subangular blocky structure; friable when moist; pH 6.0
A ₃	14"-17"	Very dark gray (10YR 3/1) clay loam with dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) streaks; moderately developed fine and very fine subangular blocky structure; friable when moist; pH 6.9
B ₂	17"-22"	Variegated olive brown (2.5Y 4/4), very dark grayish brown (2.5Y 3/2), and light olive brown (2.5Y 5/4) clay loam; moderate fine subangular blocky structure; friable when moist; very slight effervescence
C _{1ca}	22"-30"	Olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4) clay loam; structureless to weakly developed fine and medium subangular blocks; friable when moist, soft white calcium concretions common; strong effervescence
C ₂	30"+	Light olive brown (2.5Y 5/4) to olive brown (2.5Y 4/4) heavy silt loam with common medium and prominent strong brown (7.5YR 5/8) mottles; structureless; friable when moist; strong effervescence

NOTE: Colors given for moist soil

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-8	41.1	27.9	25.4	24.0	20.6	18.7	16.2	14.8	13.6
8-14	38.4	27.2	25.0	24.5	20.1	18.6	16.3	15.1	13.7
14-17	36.7	26.3	24.8	23.4	20.4	20.3	17.5	13.8	11.9
17-22	35.6	25.9	24.6	23.1	20.4	18.1	14.8	12.6	11.9
22-30	33.5	25.0	23.5	22.1	20.8	17.4	14.0	10.1	9.3
30+	32.1	24.7	23.0	22.0	18.6	16.8	12.6	9.6	9.2
36-48	35.7	25.6	22.8	20.6	19.0	18.2	14.8	13.1	12.0
48-60	32.8	25.6	24.0	22.5	19.4	17.5	15.1	13.3	12.1

AVAILABLE MOISTURE AND PARTICLE SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-8	1.24	32.1	30.9	37.0	0.18	1.44	2.80
8-14	1.27	33.5	30.3	36.2	.17	1.02	2.04
14-17	1.31	31.8	31.0	37.2	.18	.54	1.02
17-22	1.40	30.5	29.4	40.1	.19	.95	1.80
22-30	1.44	28.4	28.7	42.9	.23	1.84	2.88
30+	1.48	31.1	30.1	38.8	.22	1.32	2.16
36-48	1.56				.21	2.52	4.80
48-60	1.58				.21	<u>2.52</u>	<u>4.80</u>
Total in a 5-foot profile...						12.15	22.30

SOIL MOISTURE DESCRIPTIONSample 3

Soil Type: Barnes Loam

Location: Otter Tail County, SE 1/4 of NW 1/4, Section 22, T.131N, R.44W

Parent Material: Calcareous gray till

Classification: Chernozem

Relief: Convex

Drainage: Well drained

Slope: 2 percent

Horizon	Depth	Description
A _p	0"-7"	Black (10YR 2/1) loam to clay loam; cloddy structure; friable when moist; pH 7.0
B ₁	7"-10"	Very dark grayish brown (10YR 3/2) to very dark brown (10YR 2/2) clay loam; weak to moderately massive and fine prismatic structure; very friable when moist; pH 7.1
B ₂	10"-14"	Very dark grayish brown (10YR 3/2) clay loam; weak to moderately developed fine and medium prismatic structure; very friable when moist; pH 7.6
C _{1ca}	14"-20"	Dark grayish brown (2.5Y 4/2) clay loam; massive parent material; very friable when moist; violent effervescence
C _{2ca}	20"-30"	Grayish brown (2.5Y 5/2) loam-clay loam; massive parent material; very friable when moist; violent effervescence
C _{3ca}	30"-61"	Grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) clay loam; massive parent material; violent effervescence

NOTE: Colors given for moist soil

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
1-6	32.6	29.2	27.1	25.3	21.6	18.8	17.0	16.6	15.2
8-10	31.8	26.5	24.9	23.8	20.4	17.2	16.0	16.0	14.9
11-14	33.9	26.1	24.0	22.8	18.7	17.1	15.7	15.4	14.4
15-18	29.2	23.8	22.1	21.0	19.8	15.4	14.0	12.6	11.8
23-27	32.6	28.0	25.6	23.8	21.4	18.2	15.6	12.8	11.5
53-61	32.0	26.7	25.2	24.1	20.9	18.4	15.9	13.6	12.5

AVAILABLE MOISTURE AND PROFILE SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
1-6	1.28	39.3	29.8	30.9	0.18	1.26	2.59
8-10	1.23	37.8	25.2	37.0	.15	.45	.99
11-14	1.28	27.3	27.3	45.4	.15	.60	1.32
15-18	1.34	28.2	28.7	43.1	.16	.96	1.92
23-27	1.38	27.4	29.7	42.9	.23	4.60	7.80
53-61	1.62	30.1	31.1	38.8	.23	<u>4.60</u>	<u>8.60</u>
Total in a 5-foot profile...						12.47	23.22

SOIL PROFILE DESCRIPTIONSample 4

Soil Type: Barnes Clay Loam

Location: Chippewa County, NW 1/4, Section 4, Granite Falls Tp., T.116N, R.39W

Parent Material: Glacial till

Classification: Chernozem

Drainage: Well drained

Relief: Gently sloping

Slope: 3 percent

Horizon	Depth	Description
A _p	0"-7"	Black (10YR 2/1) clay loam; massive structure; friable when moist; slight effervescence
B ₂	7"-16"	Dark grayish brown (10YR 4/2) clay loam; weakly developed medium subangular blocky structure; friable when moist; slight effervescence
C ₁	16"-23"	Brown (10YR 5/3) clay loam with white (10YR 8/2) calcium concretions; friable when moist; strong effervescence. Pebbly layer at 22"
C _{ca}	23"-36"	Light olive brown (2.5Y 5/4) clay loam; friable when moist; violent effervescence
C ₁₃	36"-42"	Light olive brown (2.5Y 5/4) clay loam; friable when moist; strong effervescence

NOTE: Colors given for moist soil

Barnes Clay Loam
Chippewa County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-7	35.8	27.0	25.0	23.6	20.9	17.8	16.0	14.3	13.8
7-16	35.2	27.2	25.8	24.8	21.8	19.4	17.8	16.3	15.5
16-23	26.3	20.5	19.8	17.6	15.4	13.1	11.8	10.8	10.2
24-36	37.8	30.4	28.3	26.6	23.4	20.5	18.4	16.3	14.8
36-48	37.4	30.8	29.1	27.6	24.9	21.3	18.0	15.7	14.1
48-60	38.1	33.8	31.9	30.2	26.4	23.6	20.0	17.0	15.1

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-7	1.20	33.3	32.8	33.9	0.15	1.05	2.24
7-16	1.25	34.9	26.4	38.7	.15	1.35	3.06
16-23	1.42	41.4	23.9	34.7	.15	1.20	2.32
24-36	1.47	30.0	27.2	42.8	.23	2.76	5.40
36-48	1.49	29.3	31.0	42.7	.25	3.00	5.52
48-60	1.52	39.5	29.7	30.8	.28	<u>3.36</u>	<u>6.12</u>

Total in a 5-foot profile... 12.72 24.46

SOIL PROFILE DESCRIPTIONSample 5

Soil Type: Barnes Clay Loam (undulating slightly eroded phase)

Location: Lyon County, SE 1/4 of SE 1/4, Section 24, T.109N, R.40W

Parent Material: Calcareous Mankato-Cary glacial till

Classification: Chernozem

Drainage: Well drained

Relief: Convex

Slope: 2-3 percent

Horizon	Depth	Description
A _{1p}	0"-8"	Black (10YR 2/1) clay loam; structureless; slightly sticky when wet; pH 5.9
A ₁₂	8"-11"	Black (10YR 2/1) and very dark brown (10YR 2/2) loam-clay loam; weakly developed very fine and fine subangular blocky structure; friable when moist; pH 6.2
B ₁	11"-15"	Variegated brown (10YR 4/3), dark brown (10YR 3/3), and very dark brown (10YR 2/2) clay loam with very dark gray (10YR 3/1) worm casts; moderately developed fine and very fine subangular blocky structure; friable when moist; pH 6.1
B ₂₁	15"-22"	Brown (10YR 4/3) clay loam with very dark gray (10YR 3/1) worm casts; weakly developed coarse prismatic structure which breaks into fine and medium subangular blocky structure; friable when moist; pH 6.3
B ₂₂	22"-29"	Dark grayish brown (10YR 4/2) to olive brown (2.5Y 4/4) clay loam; weakly developed coarse prismatic structure breaking into medium subangular blocky structure; pH 7.1
C ₁	29"-34"	Olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4) clay loam; breaks rapidly into fragments; friable when moist; weak effervescence
C ₂	34"+	Light olive brown (2.5Y 5/4) and grayish brown (2.5Y 5/2) clay loam with common medium and prominent strong brown (7.5YR 5/8) mottles becoming stronger and larger with depth; breaks rapidly into fragments; strong effervescence

NOTE: Colors given for moist soil

Barnes Clay Loam
Lyon County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-8	37.9	26.9	26.4	25.9	19.9	18.2	17.0	15.1	14.3
8-11	38.4	27.0	24.4	23.6	20.4	18.6	17.0	15.0	14.1
11-15	34.3	25.8	23.3	22.7	19.6	17.7	15.8	14.4	13.3
15-22	33.5	26.1	23.6	22.2	19.0	17.0	14.8	13.6	12.7
22-29	34.4	25.4	23.6	22.3	19.7	16.6	14.7	13.1	12.4
29-34	34.7	25.1	23.3	22.3	18.3	16.4	13.8	12.1	11.2
34-36	36.0	27.5	25.6	24.8	21.4	18.8	14.2	13.8	10.8
36-48	32.4	23.7	22.8	21.5	17.8	16.2	13.6	11.5	10.5
48-60	32.0	24.2	22.4	21.3	18.0	16.2	14.0	12.0	10.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-8	1.28	34.0	28.9	37.1	0.16	1.28	2.72
8-11	1.27	33.2	29.8	37.0	.16	.48	1.02
11-15	1.32	35.2	24.7	40.1	.16	.64	1.36
15-22	1.44	35.8	25.1	39.1	.20	1.40	2.66
22-29	1.45	34.8	26.2	39.0	.19	1.33	2.59
29-34	1.47				.21	1.05	1.85
34-36	1.47	32.2	31.2	36.6	.24	.48	.80
36-48	1.47	45.9	17.6	36.5	.20	2.40	4.20
48-60	1.48	58.3	8.2	33.5	.20	2.40	4.32

Total in a 5-foot profile... 11.46 21.52

SOIL PROFILE DESCRIPTIONSample 6

Soil Type: Bearden Silt Loam

Location: Wilkin County, NW 1/4 of NW 1/4 of NW 1/4, Section 9, Deerhorn Tp.,
T.136N, R.47W

Parent Material: Highly calcareous lacustrine silts

Classification: Chernozem

Drainage: Somewhat poorly drained

Relief: Nearly level

Slope: 0-1/2 percent

Horizon	Depth	Description
A _p	0"-8"	Black (10YR 2/1) silt loam; cloddy structure; friable when moist; strong effervescence
C _{ca}	8"-16"	Dark gray (5Y 4/1) and gray (5Y 5/1) silt loam; parent material; very friable when moist; violent effervescence
C ₁	16"-22"	Olive gray (5Y 5/2) to gray (5Y 5/1) silt loam with very small and diffused olive (5Y 5/4) mottles; parent material, weakly developed very fine angular blocky structure; strong effervescence; pebbly
C _{2g}	22"-40"	Olive gray (5Y 5/2) silt loam with common fine faint olive (2.5Y 5/6) mottles; massive parent material
C _{3g}	40"-50"	Olive (5Y 5/3) and light olive gray (5Y 6/2) silt loam with common faint light olive brown (2.5Y 5/6) and a few distinct yellowish brown (10YR 5/8) mottles; varved parent material
C _{4g}	55"-73"	Olive gray (5Y 5/2) and light olive gray (5Y 6/2) silt loam with common medium prominent olive (5Y 5/6) mottles; varved parent material

NOTE: Colors given for moist soil

Bearden Silt Loam
Wilkin County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
1-5	44.1	32.5	30.3	28.8	25.8	22.6	20.0	18.0	16.9
9-15	28.6	20.9	19.9	19.2	16.3	14.7	13.2	12.5	11.4
17-21	28.8	24.0	21.8	20.0	17.6	14.8	13.7	11.0	10.6
24-32	35.3	30.1	28.0	26.8	23.5	19.6	18.2	14.7	14.4
47-52	40.4	34.0	32.5	31.5	29.4	25.4	19.6	16.6	14.2
62-72	40.1	33.8	32.6	31.6	28.2	24.6	18.6	13.1	14.6

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
1-5	1.17	31.1	29.5	39.4	0.20	1.40	2.66
9-15	1.50	30.4	24.2	45.4	.13	1.17	2.79
17-32	1.52	19.1	31.2	49.7	.20	1.20	2.16
24-32	1.46	21.0	33.6*	45.4*	.23	4.14	7.92
47-52	1.43	7.5	38.9	53.6	.29	4.93	8.33
62-72	1.43	7.6	45.0	47.4	.27	<u>.81</u>	<u>1.44</u>

Total in a 5-foot profile... 13.65 25.30

*Estimated value

SOIL PROFILE DESCRIPTIONSample 7

Soil Type: Dickinson Sandy Loam

Location: Redwood County, SE 1/4 of SW 1/4 of SE 1/4, Section 17, T.109N,
R.46W

Parent Material: Sandy glacial till

Classification: Prairie

Drainage: Somewhat excessively drained

Relief: Very gently undulating

Slope: 1-2 percent

Horizon	Depth	Description
A _p	0"-8"	Black (10YR 2/1) sandy loam; massive structure; very friable when moist; pH 6.3
AB	8"-12"	Very dark brown (10YR 2/2) sandy loam; very weakly developed medium subangular blocky structure to single grain; very friable when moist; pH 6.3
B ₂₁	12"-18"	Dark brown (10YR 3/3) to very dark grayish brown (10YR 3/2) light sandy loam; very weakly developed medium subangular blocky structure to single grain; very friable when moist; pH 6.4
B ₂₂	18"-26"	Brown to dark brown (10YR 4/3-3/3) loamy sand; single grain to very weakly developed coarse subangular blocky structure; very friable when moist; pH 6.3
B ₃	26"-35"	Dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4, 5/6, and 5/8) medium sands; single grain; very friable when moist; pH 6.3
C ₁	35"-42"	Yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) medium and coarse sands; single grain; very friable when moist; very weak effervescence
C ₂	42"-60"	Brown (7.5YR 4/4) and strong brown (7.5YR 5/6 and 5/8) coarse sand and fine gravel with iron streaks of yellowish red (5YR 4/6) and dark red (2.5YR 3/6); single grain; weak effervescence, becoming stronger with depth

NOTE: Colors given for moist soil

Dickinson Sandy Loam
Redwood County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-8	20.7	14.4	13.3	11.4	10.0	9.2	7.8	6.9	6.7
8-12	17.1	12.9	11.0	8.8	8.8	6.9	6.3	5.4	5.1
12-18	14.1	10.1	9.0	8.4	7.2	6.2	5.6	5.4	4.3
18-26	10.3	7.6	6.5	6.0	5.8	4.6	3.9	3.6	3.5
26-35	7.4	5.8	5.4	5.2	4.4	4.2	3.8	3.1	3.2
35-42	7.1	5.6	4.9	4.4	4.0	3.7	3.5	3.4	3.1
42-60	5.5	4.6	4.2	3.8	3.1	3.0	2.5	2.4	2.1

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-8	1.46	76.5	13.0	10.5	0.11	0.88	1.68
8-12	1.50	77.2	11.8	11.0	.11	.44	.76
12-18	1.57	76.9	12.0	11.1	.09	.54	.96
18-26	1.66	85.5	5.4	9.1	.07	.56	1.04
26-35	1.67	88.3	2.6	9.1	.05	.45	.90
35-42	1.71	89.0	1.9	9.1	.05	.35	.70
42-60	1.53	91.6	2.4	6.0	.04	.72	1.26

Total in a 5-foot profile... 3.94 7.30

SOIL PROFILE DESCRIPTIONSample 8

Soil Type: Fargo Silty Clay

Location: Wilkin County, NE 1/4 of SE 1/4, Section 6, Nordick Tp., T.134N,
R.47W

Parent Material: Fine textured calcareous lacustrine clay

Classification: Humic Gley

Drainage: Poorly drained

Relief: Smooth

Slope: 0-1/2 percent

Horizon	Depth	Description
A _p	0"-8"	Black (10YR 2/1) silty clay; cloddy structure; firm when moist; pH 6.9
B _{g1}	8"-12"	Very dark gray (5Y 3/1) silty clay; moderately developed very fine angular blocky structure; firm when moist; pH 6.4
B _{g2}	12"-19"	Dark gray (5Y 4/1) to very dark gray (5Y 3/1) silty clay; moderately developed very fine angular blocky structure; firm when moist; slight effervescence; pH 7.6
C _{g1}	19"-24"	Dark gray (5Y 4/1) silty clay with common fine olive gray (5Y 4/2) mottles; weakly developed fine angular blocky structure; friable when moist; strong effervescence
C _{g2}	24"-40"	Dark gray (5Y 4/1) and olive gray (5Y 4/2) silty clay; weakly developed fine angular blocky structure; friable when moist; free lime present; strong effervescence
C _{g3}	40"-45"	Olive gray (5Y 4/2) and olive (5Y 4/3) silty clay with few distinct light olive brown (2.5Y 5/6) mottles; massive parent material; firm when moist; strong effervescence
C _{g4}	45"-58"	Olive gray (5Y 5/2) silty clay with many faint olive (5Y 5/6) and a few prominent yellowish brown (10YR 5/8) mottles; massive parent material; firm when moist; strong effervescence
C _{g5}	58"-78"	Gray (5Y 5/1) and olive gray (5Y 5/2) silty clay with common prominent yellowish brown (10YR 5/8) mottles; varved parent material; firm when moist; strong effervescence

NOTE: Colors given for moist soil

Fargo Silty Clay
Wilkin County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
1-7	43.9	35.2	32.7	31.1	27.8	26.4	22.4	19.4	18.9
9-11	42.3	37.8	36.2	34.6	34.6	29.6	27.4	23.8	22.9
13-17	45.4	38.7	36.5	34.8	32.1	27.7	27.0	23.6	23.0
20-23	42.5	34.3	32.6	31.5	30.8	24.9	24.5	21.8	20.4
27-30	40.6	33.1	31.8	31.1	29.0	24.3	23.3	20.7	20.0
40-45	46.9	39.7	37.3	35.9	31.1	27.7	25.8	22.6	21.8
52-55	50.2	41.7	39.1	37.0	33.6	30.1	28.2	24.3	23.5
70-74	53.9	45.0	41.9	39.7	39.2	36.0	31.6	27.4	24.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
1-7	1.16	23.4	21.3	55.3	0.19	1.52	3.28
9-11	1.32	12.2	14.4	74.4	.20	.80	2.00
13-17	1.38	8.5	14.9	76.6	.21	1.26	3.18
20-23	1.32	7.0	12.7	80.3	.18	1.26	3.15
27-30	1.46	3.3	10.3	86.4	.19	1.90	4.80
40-45	1.49	3.0	12.6	84.4	.27	3.51	7.67
52-55	1.43	1.3	12.6	86.1	.26	4.16	9.60
70-74	1.43	1.8	16.7	81.5	.29	<u>2.90</u>	<u>6.40</u>

Total in a 5-foot profile... 13.37 31.28

SOIL PROFILE DESCRIPTIONSample 9

Soil Type: Fayette Silt Loam (upland phase)

Location: Wabasha County, SE 1/4 of SE 1/4, Section 2, T.109N R.11W

Parent Material: Loess

Classification: Gray-Brown Podzolle

Relief: B

Drainage: Well drained

Slope: 5 percent

Horizon	Depth	Description
A _p	0"-8"	Very dark grayish brown (10YR 3/2) silt loam; moderate fine granular structure; friable; pH 7.5
B ₁	8"-11"	Dark grayish brown (10YR 4/2) to dark brown (10YR 3/3) silt loam; weak to moderate medium subangular blocky structure; friable; pH 7.3
B ₂₁	11"-19"	Dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) silty clay loam with white (10YR 8/2) silica coats; strong medium angular blocky structure breaking to strong fine angular blocky structure; friable to firm; pH 6.3
B ₂₂	19"-28"	Dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) silt loam with very dark brown (10YR 2/2) faces; strong medium angular blocky structure; firm; pH 5.8
B ₃	28"-36"	Dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) silt loam; moderate to medium angular blocky to massive structure; friable; pH 5.5
C ₁	36"-50"	Dark grayish brown (10YR 4/2) to dark brown (10YR 4/3) silt loam; massive structure; friable; pH 5.5
C ₂	50"+	Yellowish brown (10YR 5/4) silt loam; massive structure; friable; pH 5.5

NOTE: Colors given for moist soil

Fayette Silt Loam (upland phase)
Wabasha County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	36.7	24.4	19.6	17.9	17.2	10.9	9.9	8.1	7.4
6-12	37.9	26.6	22.8	20.5	19.2	15.6	10.2	9.5	8.9
12-18	39.1	27.1	23.3	21.5	20.1	17.0	13.2	11.3	10.8
18-24	41.5	27.7	23.2	21.3	20.9	16.7	13.2	11.4	10.8
24-36	41.0	29.6	24.0	21.6	20.6	17.0	13.5	11.6	10.9
36-48	41.4	29.7	25.2	22.2	20.4	17.6	14.0	11.9	11.3
48-60	39.5	27.8	22.0	22.4	17.3	14.8	11.4	9.8	9.3

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	1.34	13.2	64.7	22.1	0.23	1.37	1.96
6-12	1.43	10.8	59.9	29.3	.25	1.52	2.28
12-18	1.37	14.7	56.0	29.3	.22	1.34	2.23
18-24	1.29	9.0	61.7	29.3	.21	1.28	2.14
24-36	1.36	9.6	60.1	30.3	.26	3.06	4.83
36-48	1.36	10.2	59.5	30.3	.25	3.00	4.85
48-60	1.41	10.8	64.0	25.2	.23	2.80	4.70

Total in a 5-foot profile... 14.37 22.99

SOIL PROFILE DESCRIPTIONSample 10

Soil Type: Kranzburg Silt Loam

Location: Pipestone County, SE 1/4 of SE 1/4, Section 19, T.107N, R.45W

Parent Material: Loess over pre-Mankato-Cary glacial till

Classification: Chernozem

Drainage: Well drained

Relief: Gently sloping

Slope: 3-4 percent

Horizon	Depth	Description
A _{1p}	0"-7"	Very dark gray (10YR 3/1) silt loam; weak very fine subangular blocky structure; friable when moist; pH 5.9
A ₁₂	7"-10"	Black (10YR 2/1) and very dark gray (10YR 3/1) silt loam; moderate to strongly developed fine subangular blocky structure; very friable when moist; pH 6.0
B ₁	10"-13"	Very dark grayish brown (10YR 3/2) to very dark gray (10YR 3/1) silt loam; weak fine subangular blocky structure; pH 5.6
B ₂₁	13"-19"	Dark brown (10YR 3/3) to very dark grayish brown (10YR 3/2) silt loam; moderately developed medium and fine subangular blocky structure; soft when dry; pH 6.0
B ₂₂	19"-25"	Dark grayish brown (10YR 4/2) to brown (10YR 4/3) silt loam; moderately developed coarse and medium prismatic structure which breaks into weak medium subangular blocky structure; pH 6.3
B ₃	25"-29"	Olive brown (2.5Y 4/4) to dark yellowish brown (10YR 4/4) heavy silt loam; weakly developed medium subangular blocky structure; pH 7.4
C ₁	29"-32"	Dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/4) heavy silt loam; structureless to weakly developed medium subangular blocky structure; few calcium concretions present; slight effervescence
C ₂	32"+	Light olive brown (2.5Y 5/4) to olive brown (2.5Y 4/4) clay loam; structureless; soft white calcium concretions present; strong effervescence

NOTE: Colors given for moist soil

Kranzburg Silt Loam
Pipestone County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-7	46.6	31.8	27.9	25.3	22.2	19.4	16.3	14.3	13.5
7-10	46.8	33.5	29.6	26.6	22.4	20.4	17.0	14.7	13.9
10-13	48.3	32.0	29.0	26.9	22.1	19.8	16.6	14.4	13.6
13-19	44.5	31.2	28.0	25.7	22.0	20.8	15.7	13.9	13.1
19-25	36.6	28.2	25.2	22.7	18.6	17.0	14.3	12.8	11.9
25-29	36.2	25.2	23.4	21.9	17.9	15.6	13.7	12.5	11.7
29-32	35.5	24.2	22.5	20.7	17.3	14.6	13.2	11.2	10.4
32-36	31.9	24.7	22.4	20.4	17.0	14.6	12.4	10.5	9.7
36-42	32.0	25.3	23.2	21.4	18.2	14.0	14.0	11.6	10.6
48-60	32.2	25.4	23.8	22.3	18.5	14.0	14.0	11.8	10.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-7	1.28	16.0	51.3	32.7	0.24	1.68	2.87
7-10	1.22	13.8	51.3	34.9	.24	.72	1.23
10-13	1.28	13.7	49.4	36.9	.24	.72	1.23
13-19	1.38	13.1	48.0	38.9	.25	1.50	2.58
19-25	1.48	19.1	41.7	39.2	.24	1.44	2.52
25-29	1.50	47.3	26.3	26.4	.20	.80	1.52
29-32	1.53	24.7	36.7	38.6	.21	.63	1.11
32-36	1.55				.23	.92	1.52
36-42	1.58				.23	1.84	3.20
48-60	1.63				.23	3.68	6.56

Total in a 5-foot profile... 13.93 24.34

SOIL PROFILE DESCRIPTIONSample 11

Soil Type: Moody Silt Loam

Location: Rock County, SW 1/4 of SW 1/4 of SW 1/4, Section 6, Kanaranzi Tp.,
T.101N, R.44W

Parent Material: Calcareous loess over calcareous glacial till

Classification: Chernozem

Drainage: Well drained

Relief: Convex

Slope: 3 percent

Horizon	Depth	Description
A _{1p}	0"-7"	Very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) silt loam; weak fine subangular blocky structure; very friable when moist; pH 6.2
A ₁₂	7"-12"	Very dark grayish brown (10YR 3/2) silt loam; weak to moderate medium subangular blocky structure; friable when moist; pH 6.5
AB	12"-16"	Very dark grayish brown (10YR 3/2) to dark grayish brown (10YR 4/2) silt loam; moderate medium subangular blocky structure; firm when moist; pH 7.0
B ₂₁	16"-20"	Dark brown (10YR 4/3) silty clay loam; moderately developed medium subangular blocky structure; firm when moist; pH 7.0
B ₂₂	20"-24"	Brown (10YR 5/3) silty clay loam; moderately developed coarse subangular blocky structure; firm when moist pH 7.0
C ₁	24"-36"	Light yellowish brown (10YR 6/4) silt loam; structureless to weakly developed fine subangular blocky structure; friable when moist; strong effervescence
C _{ca}	36"+	Light gray (10YR 7/2) to light yellowish brown (10YR 6/4) silt loam; massive structure; very friable when moist; free lime present; violent effervescence

NOTE: Colors given for moist soil

Depth (inches)	Percent water to respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-7	42.1	31.2	27.8	26.3	25.2	19.6	16.7	14.7	13.6
7-12	39.8	30.8	28.3	26.5	24.4	20.6	17.4	15.0	13.7
12-17	39.9	30.5	28.2	26.4	24.5	20.0	17.5	15.2	14.1
17-22	37.8	27.6	25.3	23.3	20.4	16.2	14.8	13.2	12.0
24+	38.5	28.2	24.4	22.0	19.8	14.8	13.2	11.7	10.8

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-7	1.23	12.0	52.2	35.8	0.22	1.54	2.73
7-12	1.20	12.8	53.4	33.8	.21	1.05	1.85
12-17	1.24	13.5	49.6	36.9	.20	1.00	1.90
17-22	1.29	13.6	49.5	36.9	.20	1.20	2.16
24+	1.32	11.7	55.6	32.7	.23	8.51	13.69

Total in a 5-foot profile...	13.30	22.33
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SOIL PROFILE DESCRIPTIONSample 12

Soil Type: Mora Silt Loam

Location: Mille Lacs County, SW 1/4 of SW 1/4, Section 19, T.38N, R.26W

Parent Material: Red till with shallow silt cap

Classification: Gray-Brown Podzolic

Relief: 3-6 ft.

Drainage: Moderately well to somewhat poorly drained

Slope: 1-2 percent

Horizon	Depth	Description
A _p	0"-7"	Dark brown (10YR 3/3) silt loam; structureless to weak very fine subangular blocky structure; friable; pH 6.2
A ₂	7"-16"	Brown (10YR 5/3) to grayish brown (10YR 5/2) silt loam with a few fine faint yellowish brown (10YR 5/4) mottles; structureless to weak medium platy structures; friable; pH 4.8
B ₁	16"-20"	Gray brown (10YR 5/2) loam with common medium distinct dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6) mottles; weak medium platy structure; friable; pH 5.1
B ₂₁	20"-22"	Brown (7.5YR 5/4) loam with common medium distinct dark reddish brown (5YR 3/4) to yellowish red (5YR 4/8) mottles; moderate fine subangular blocky structure; friable; pH 4.8
B _{22m}	22"-25"	Dark reddish brown (5YR 3/4) sandy clay loam with common medium faint to distinct reddish brown (5YR 4/3 and 5/3) mottles; moderate fine subangular blocky structure; friable to firm; pH 5.4
C _m	25"-40"	Variegated dark reddish brown (5YR 3/2 and 3/4) to yellowish red (5YR 3/16 3/3) sandy loam; horizontal platy structure; firm; pH 5.3

NOTE: Colors given for moist soil

Mora Silt Loam
Mille Lacs County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	38.9	24.7	20.0	17.5	14.9	12.2	8.5	6.8	6.0
6-12	33.6	22.1	18.4	15.0	13.1	10.7	7.4	5.4	4.9
12-18	30.8	22.8	17.0	14.9	13.3	11.8	8.4	6.8	6.5
18-24	26.5	17.5	14.4	12.8	11.8	10.6	8.3	7.1	6.4
24-36	19.7	12.6	10.5	10.2	9.3	8.0	6.3	5.2	4.9
36-48	16.3	10.8	9.7	9.4	8.0	7.3	5.9	4.9	4.5
48-60	16.0	12.7	9.6	9.1	8.1	7.0	5.4	4.6	4.2

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk* density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	1.4	23.1	58.7	18.2	0.26	1.57	2.07
6-12	1.4	25.1	58.1	16.8	.24	1.47	1.86
12-18	1.4	28.6	47.5	23.9	.23	1.37	1.92
18-24	1.4	45.0	34.1	20.9	.16	.93	1.47
24-36	1.4	59.0	25.2	15.8	.10	1.24	2.12
36-48	1.4	61.3	21.2	17.5	.09	1.06	1.81
48-60	1.4	63.3	23.2	13.5	.12	1.42	2.13
Total in a 5-foot profile...						9.06	13.38

*Estimate only; no data available.

SOIL PROFILE DESCRIPTIONSample 13

Soil Type: Nicollet Clay Loam

Location: Sibley County, NE 1/4 of NE 1/4, Section 4, Cornish Tp., T.112N,
R.30W

Parent Material: Friable gray calcareous till

Classification: Prairie

Drainage: Moderately well drained

Relief: Undulating

Slope: A(1-2 percent)

Horizon	Depth	Description
A _{1p}	0"-9"	Black (10YR 2/1) clay loam; weak to moderate fine and very fine subangular blocky structure; friable; pH 7.0
A ₁	9"-12"	Black (10YR 2/1) clay; weak to moderate very fine and fine subangular blocky structure; friable; pH 6.5
A ₃	12"-16"	Very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) clay; weak fine subangular blocky; friable; pH 6.3
B ₂₁	16"-23"	Dark grayish brown (2.5Y 4/2 and 10YR 4/2) clay; weak fine and medium subangular blocky structure; friable to firm; pH 6.2
B ₂₂	23"-34"	Olive brown (2.5Y 4/4) clay loam with common medium distinct dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) mottles; weak medium and fine subangular blocky structure; firm; pH 6.0
C ₁	34"-37"	Olive brown (2.5Y 4/4) to light olive brown (2.5Y 5/4) clay loam with common medium distinct grayish brown (2.5Y 5/2) mottles; massive structure; friable; slight effervescence.
C		Light olive brown (2.5Y 5/4) clay loam with common medium distinct olive brown (2.5Y 4/4) and grayish brown (2.5Y 5/2) mottles; massive structure; friable; violent effervescence.

NOTE: Colors given for moist soil

Nicollet Clay Loam
Sibley County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	44.8	32.8	30.7	29.5	27.2	25.5	20.7	18.5	18.3
6-12	46.9	30.6	30.2	28.8	27.0	24.7	19.9	17.8	17.2
12-18	44.3	32.2	30.0	28.5	26.4	25.0	20.2	18.0	17.0
18-24	41.5	30.6	29.2	27.7	25.7	24.2	19.7	17.7	16.8
24-36	39.0	29.0	26.9	26.3	24.1	22.8	17.7	15.7	14.3
36-48	36.9	28.2	26.4	25.5	23.2	21.5	16.9	14.5	13.4
48-60	35.9	26.3	25.0	24.8	22.6	20.8	16.2	13.9	12.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	0.98	23.6	41.1	35.3	0.14	0.85	1.93
6-12	1.20	21.0	36.7	42.3	.16	.96	2.20
12-18	1.22	23.2	34.3	42.5	.19	1.11	2.36
18-24	1.26	27.9	31.1	40.4	.17	1.04	2.31
24-36	1.26	28.2	36.7	35.1	.19	2.22	4.38
36-48	1.39	34.4	30.6	35.0	.21	2.46	4.60
48-60	1.46	37.0	30.1	32.9	.18	2.20	4.61

Total in a 5-foot profile... 10.84 22.39

SOIL PROFILE DESCRIPTIONSample 14

Soil Type: Nicollet Clay Loam

Location: Watonwan County, SE 1/4 of NE 1/4 of NW 1/4, Section 21, Odin Tp.,
T.105N, R.33W

Parent Material: Fine calcareous till

Classification: Prairie

Drainage: Somewhat poorly drained

Relief: Nearly level

Slope: 1 percent

Horizon	Depth	Description
A _p	0"-8"	Very dark gray (10YR 3/1) clay loam; cloddy structure; friable; pH 5.8
A ₁	8"-12"	Very dark gray (10YR 3/1) clay loam; moderate fine to medium subangular blocky structure; friable; pH 5.8
B ₁	12"-17"	Very dark grayish brown (10YR 3/2) to dark yellowish brown (10YR 4/4) clay loam; moderate fine to medium subangular blocky structure; friable; pH 6.0
B ₂	17"-23"	Brown (10YR 5/3) to yellowish brown (10YR 5/4) clay loam mixed with very dark gray (10YR 3/1) earthwormy channels; moderate fine to medium subangular blocky structures; friable; pH 6.3
B ₃	23"-27"	Olive gray (5Y 4/2) to olive (5Y 4/3) clay loam; weak very fine subangular blocky structure; friable; pH 7.0
C ₁	27"-52"	Olive (5Y 5/3 and 5/4) clay loam with yellowish red (5YR 5/8) mottles; massive structure; firm; strong effervescence

NOTE: Colors given for moist soil

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	35.7	26.3	23.8	22.6	21.1	18.9	16.1	14.1	13.3
6-12	36.8	26.7	23.1	23.1	21.9	19.9	16.3	14.4	13.7
12-18	34.8	25.8	23.2	22.6	21.1	18.6	15.6	13.6	13.2
18-24	34.9	24.5	22.2	21.6	20.3	18.1	14.5	12.3	11.7
24-36	32.0	23.6	20.4	19.9	18.3	16.3	13.0	10.7	10.0
36-48	32.5	25.3	21.9	20.6	19.4	17.2	13.4	11.2	11.0
48-60	32.5	25.7	23.0	21.6	19.3	16.7	12.5	10.4	9.7

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	1.31	36.0	28.6	35.4	0.17	1.02	2.07
6-12	1.30	34.4	30.2	35.4	.17	1.01	2.08
12-18	1.34	35.6	27.0	37.4	.17	1.01	2.07
18-24	1.41	35.5	27.2	37.3	.18	1.08	2.07
24-36	1.47	40.4	30.5	29.1	.20	2.40	4.16
36-48	1.44	40.4	27.5	32.1	.21	2.48	4.37
48-60	1.49	37.5	32.5	30.0	.24	2.86	4.60

Total in a 5-foot profile...	11.86	21.42
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SOIL PROFILE DESCRIPTIONSample 15

Soil Type: Rothsay Silt Loam (Heimdahl farm)

Location: Lac qui Parle County, SE 1/4 of SE 1/4 of SE 1/4, Section 9,
Lac qui Parle Tp., T.118N, R.42W

Parent Material: Water laid silts

Classification: Chernozem

Relief: Gently sloping

Drainage: Well drained

Slope: 3 percent, simple convex

Horizon	Depth	Description
A _{1p}	0"-8"	Black (10YR 2/1) to very dark brown (10YR 2/2) silt loam; cloddy structure; friable when moist; pH 5.8
B ₁	8"-11"	Very dark grayish brown (10YR 3/2) and brown (10YR 4/3) silt loam with black (10YR 2/1) worm casts; weak fine subangular blocky structure; very friable when moist; pH 5.8
B ₂₁	11"-16"	Dark brown (10YR 3/3) to brown (10YR 4/3) silt loam; weakly developed medium and coarse prismatic structure which breaks into weak fine subangular blocky structure; very friable when moist; pH 6.1
B ₂₂	16"-26"	Dark yellowish brown (10YR 4/4) silt loam; very weak medium subangular blocky structure; very friable when moist; pH 6.3
B ₃	26"-31"	Olive brown (2.5Y 4/4) silt loam with few fine distinct dark yellowish brown (10YR 4/4) mottles; structureless; very friable when moist; very weak effervescence; iron concretions present
C _{1ca}	31"-43"	Grayish brown (2.5Y 5/2) silt loam; structureless; very friable when moist; strong effervescence; soft light gray (2.5Y 7/2) lime concretions present, < 5 mm.
C _{2ca}	43"	Grayish brown (2.5Y 5/2) stratified waterlaid silt loam with common, coarse, distinct dark yellowish brown mottles; structureless; very friable when moist; strong effervescence

NOTE: Colors given for moist soil

Rothsay Slit Loam
 Lac qui Parle County
 Heimdahl farm

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-8	28.4	18.0	16.2	14.6	12.5	10.6	9.1	8.0	7.5
8-11	32.7	21.2	19.5	18.1	14.7	13.1	11.9	10.5	9.9
11-16	33.6	22.1	20.4	19.0	15.0	13.6	12.2	10.6	10.0
16-26	33.4	17.6	15.8	14.8	11.4	10.1	9.1	7.8	7.5
26-31	37.4	26.2	22.1	19.3	15.6	13.6	12.3	10.1	9.6
31-36	39.7	27.0	23.8	21.4	17.0	14.4	11.8	9.9	9.3
36-43	38.0	27.8	23.7	21.0	16.8	14.2	11.8	10.0	9.3
48+	34.3	23.0	19.8	17.2	13.4	11.4	9.3	7.6	7.3

AVAILABLE MOISTURE AND PARTICLE
 SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-8	1.50	52.3	23.3	24.4	0.16	1.28	2.16
8-11	1.39	41.8	27.6	30.6	.16	.48	.90
11-16	1.42	38.3	28.0	33.7	.17	.85	1.55
16-26	1.44	40.4	33.2	26.4	.14	1.40	2.50
26-31	1.37	24.9	44.5	30.6	.23	1.15	1.80
31-36	1.40	21.6	49.9	28.5	.25	1.25	1.90
36-43	1.45	20.4	54.2	25.4	.26	3.12	4.80
48+	1.43	27.8	52.0	20.2	.23	2.76	3.96

Total in a 5-foot profile... 12.29 19.57

SOIL PROFILE DESCRIPTIONSample 16

Soil Type: Rothsay Silt Loam (Johnson farm)

Location: Lac qui Parle County, SW 1/4 of SW 1/4, Section 15, Lac qui Parle Tp., T.118N, R.42W

Parent Material: Water deposited silts

Classification: Chernozem

Drainage: Well drained

Relief: Nearly level to gently sloping

Slope: 2-3 percent

Remarks: Presence of a 4" silty clay layer at 20" and an 8" loamy coarse sand layer at 28" makes it questionable whether this soil is a normal Rothsay silt loam

Horizon	Depth	Description
A _{1p}	0"-6"	Black (10YR 2/1) silt loam; cloddy; friable when moist; pH 5.9
A ₁₂	6"-10"	Black (10YR 2/1) to very dark gray (10YR 3/1) silt loam; weak to moderate subangular blocky structure; friable when moist; pH 6.0
B ₂₁	10"-15"	Very dark grayish brown (10YR 3/2) to dark brown (10YR 3/3) silt loam; moderately developed medium subangular blocky structure; friable when moist; pH 6.0
B ₂₂	15"-20"	Brown (10YR 4/3) silt loam; weak medium and coarse subangular blocky structure; friable when moist; pH 6.3
B ₃	20"-24"	Dark grayish brown (2.5Y 4/2) silty clay; moderately developed very fine and fine subangular blocky structure with clay skins; firm when moist; pH 6.5
C _{1ca}	24"-28"	Dark grayish brown (2.5Y 4/2) to gray brown (2.5Y 5/2) clay loam; structureless; slightly firm when moist; free lime present, light gray color (10YR 7/1); violent effervescence
D ₁	28"-36"	Dark grayish brown (2.5Y 4/2) loamy coarse sand; structureless; strong effervescence; high in shale
D ₂	36"-48"	Grayish brown (2.5Y 5/2) to light brownish gray (2.5Y 6/2) very fine sandy loam with many medium distinct dark yellowish brown (10YR 4/4) mottles; structureless; strong effervescence
D ₃	48"+	Light brownish gray (2.5Y 6/2) silt loam with many coarse distinct dark yellowish brown (10YR 4/4) mottles; structureless; strong effervescence; stratified waterlaid silts present

NOTE: Colors given for moist soil

Rothsay Silt Loam
 Lac qui Parle County
 Johnson farm

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	45.5	28.2	28.1	28.0	21.2	18.0	16.1	13.8	12.9
6-10	44.4	30.0	26.6	24.5	21.2	18.3	16.4	13.4	13.3
10-15	42.3	28.8	26.4	24.6	21.0	17.8	15.8	14.3	13.2
15-20	41.2	28.2	25.9	23.8	19.6	17.0	15.2	14.2	12.8
20-24	43.2	34.7	32.4	30.8	25.8	23.0	22.9	20.4	19.4
24-28	40.9	32.9	30.3	29.2	26.0	20.5	19.0	17.8	17.5
28-36	39.0	14.6	13.6	13.0	11.5	11.5	11.5	10.3	9.6
36-48	28.0	20.6	19.4	17.8	13.1	10.8	9.0	8.0	7.7
48-60	29.4	21.9	18.8	16.8	14.5	11.5	8.6	6.8	6.5

AVAILABLE MOISTURE AND PARTICLE
 SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	1.16	28.4	40.9	30.7	0.18	1.08	1.98
6-10	1.10	26.4	41.9	31.7	.18	.72	1.32
10-15	1.10	19.0	44.1	36.9	.18	.90	1.60
15-20	1.27	20.0	62.6	17.4	.20	1.00	1.80
20-24	1.35	19.3	34.2	46.5	.21	.84	1.88
24-28	1.44	50.9	19.5	29.6	.22	.88	1.88
28-36	1.40	39.0	29.5	31.5	.07	.56	1.60
36-48	1.36	49.0	34.8	16.2	.18	2.16	3.36
48-60	1.38	42.6	39.2	18.2	.21	2.52	3.60

Total in a 5-foot profile... 10.66 19.02

SOIL PROFILE DESCRIPTIONSample 17

Soil Type: Vienna Silty Clay Loam

Location: Nobles County, center of SE 1/4 of SE 1/4, Section 27, Leota Tp.,
T.104N, R.43W

Parent Material: Calcareous glacial till

Classification: Chernozem

Relief: Convex

Drainage: Well drained

Slope: 3-4 percent

Horizon	Depth	Description
A _{1p}	0"-7"	Very dark brown (10YR 2/2) silty clay loam; cloddy structure; friable when moist; pH 5.7
A ₁₂	7"-9"	Very dark grayish brown (10YR 3/2) silty clay loam; moderately developed medium subangular blocky structure; friable when moist; pH 6.1
AB	9"-12"	Very dark grayish brown (10YR 3/2) to dark yellowish brown (10YR 4/4) silty clay loam; moderately developed medium subangular blocky structure; friable when moist; pH 6.0
B ₂₁	12"-18"	Dark yellowish brown (10YR 4/4) silty clay loam; weakly developed fine subangular blocky structure; very friable when moist; slight effervescence
B _{22ca}	18"-22"	Light yellowish brown (10YR 6/4) to yellowish brown (10YR 5/6) clay loam; moderately developed medium subangular blocky structure; very friable when moist; violent effervescence
C _{1ca}	32"-36"	Yellowish brown (10YR 5/4) to light yellowish brown (10YR 6/4) clay loam; weakly developed fine subangular blocky structure; friable when moist; violent effervescence
C _{ca}	36"+	Light gray (10YR 7/2) to brownish yellow (10YR 6/6) clay loam; massive structure; friable when moist; free lime present; violent effervescence

NOTE: Colors given for moist soil

Vienna Silty Clay Loam
Nobles County

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-7	42.0	30.5	28.1	26.4	23.3	20.9	16.6	14.3	13.5
7-9	46.5	31.5	29.0	27.5	23.9	21.7	16.9	14.4	13.6
12-18	40.2	28.5	26.0	24.5	21.3	19.5	15.6	13.8	12.9
18-22	38.4	25.9	23.6	22.6	19.1	17.4	14.6	12.7	11.9
32-36	30.1	22.0	20.1	18.8	16.0	14.2	12.4	10.3	9.7

AVAILABLE MOISTURE AND PARTICLE SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-7	1.26	20.8	45.3	33.9	0.21	1.47	2.66
7-9	1.38	17.7	45.3	37.0	.24	.72	1.29
12-18	1.46	21.7	42.3	36.0	.23	1.84	3.36
18-22	1.55	28.1	34.9	37.0	.22	1.98	3.60
32-36	1.60	39.5	25.9	34.6	.19	<u>6.27</u>	<u>11.55</u>
Total in a 5-foot profile...						12.28	22.46

SOIL MOISTURE PROFILESample 18

Soil Type: Waukon Silt Loam (Hagen farm)

Location: Otter Tail County, NE 1/4 of SE 1/4, Section 30, Sverdrup Tp.,
T.133N, R.41W

Parent Material: Cary gray calcareous till

Classification: Degraded Chernozem

Relief: Convex

Drainage: Well drained

Slope: 3 percent

Horizon	Depth	Description
A _p	0"-6"	Black (10YR 2/1) silty clay loam; cloddy structure; very friable when moist; pH 6.8
A ₁	6"-9"	Black (10YR 2/1) silty clay loam; cloddy structure; very friable when moist; pH 6.8
B ₁	9"-11"	Very dark grayish brown (2.5Y 3/2) to dark grayish brown (2.5Y 4/2) silty clay loam with streaks of very dark gray (10YR 3/1); massive structure; firm when moist; clay skins; pH 7.0
B ₂₁	11"-14"	Dark grayish brown (2.5Y 4/2) to olive brown (2.5Y 4/4) clay loam with common distinct yellowish brown (10YR 5/8) mottles; weakly developed very fine angular blocky structure; friable when moist; slight effervescence; clay skins; pH 7.8
B ₂₂	14"-20"	Very dark grayish brown (2.5Y 3/2) to dark grayish brown (2.5Y 4/2) clay loam with common distinct yellowish brown (10YR 5/8) mottles; weak very fine angular blocky structure; friable when moist; clay skins; pH 7.8
C ₁	20"-26"	Grayish brown (2.5Y 5/2) to olive brown (2.5Y 4/4) loam; weakly developed very fine angular blocky structure; very friable when moist; strong effervescence
C ₂	26"-32"	Grayish brown (2.5Y 5/2) to olive brown (2.5Y 4/4) loam with black (10YR 2/1) root remnants; weak very fine angular blocky structure; very friable when moist; violent effervescence
C ₃	32"-66"	Grayish brown (2.5Y 5/2) to olive gray (5Y 5/2) loam with common medium and coarse prominent strong brown (7.5YR 5/8) mottles; massive parent material; firm when moist; violent effervescence

NOTE: Colors given for moist soil

Waukon Silt Loam
West Otter Tail County
Hagen farm

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
3-6	35.5	28.8	27.0	25.4	22.0	18.8	16.8	14.6	13.7
6-9	36.2	27.4	25.9	24.6	21.3	18.2	16.3	14.4	14.5
9 $\frac{1}{2}$ -10 $\frac{1}{2}$	36.0	28.6	26.9	25.6	22.9	19.6	18.2	16.0	16.1
11 $\frac{1}{2}$ -13 $\frac{1}{2}$	34.5	26.9	25.0	23.7	20.8	18.4	16.5	15.2	15.0
15-19	37.0	30.0	27.9	26.5	23.4	20.6	18.2	16.5	15.0
21-25	33.4	26.5	25.3	24.2	21.8	18.6	15.4	12.9	12.7
27-30	23.7	22.6	21.2	20.0	18.0	15.3	12.7	10.4	10.3
60-66	25.6	20.8	19.2	18.2	17.0	14.4	12.2	10.3	10.2

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in. H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
3-6	1.30	35.9	27.1	37.0	0.19	1.14	2.22
6-9	1.42	37.0	27.0	36.0	.19	.57	1.17
9 $\frac{1}{2}$ -10 $\frac{1}{2}$	1.42	33.7	23.1	43.2	.18	.36	.82
11 $\frac{1}{2}$ -13 $\frac{1}{2}$	1.42	35.3	22.6	42.1	.17	.51	1.14
15-19	1.42	35.8	23.0	41.2	.22	1.32	2.58
21-25	1.47	36.0	25.3	38.7	.20	1.20	2.34
27-30	1.52	41.1	26.4	32.5	.18	3.42	6.46
60-66	1.60	44.2	25.4	30.4	.17	<u>2.55</u>	<u>4.95</u>

Total in a 5-foot profile... 11.07 21.68

SOIL PROFILE DESCRIPTIONSample 19

Soil Type: Waukon Clay Loam (Thompson farm)

Location: Otter Tail County, NW 1/4 of SW 1/4 of SW 1/4, Section 14, Dane
Prairie Tp., T.132N, R.42W

Parent Material: Cary glacial till

Classification: Degraded Chernozem

Relief: Gently sloping

Drainage: Well drained

Slope: 3 percent

Horizon	Depth	Description
Ap	0"-6"	Black (10YR 2/1) clay loam; cloddy structure; friable when moist; pH 6.5
AB	6"-8"	Very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) clay loam; weakly developed medium granular structure; very friable when moist; A and B mixed by considerable worm action; pH 6.4
B ₁	8"-12"	Very dark grayish brown (10YR 3/2) clay loam; weak very fine subangular blocky structure; very friable when moist; discontinuous clay skins; pH 6.8
B ₂₁	12"-17"	Dark grayish brown (2.5Y 4/2) to very dark grayish brown (10YR 3/2) clay loam; weak very fine subangular blocky structure; friable when moist; discontinuous clay skins; pH 6.6
B ₂₂	17"-23"	Dark grayish brown (2.5Y 4/2) clay loam; weak very fine subangular blocky structure; friable when moist; pH 7.0
C _{ca}	23"-28"	Light olive brown (2.5Y 5/4) clay loam; massive parent material; very friable when moist; violent effervescence
C ₂	28"-43"	Light olive brown (2.5Y 5/4) clay loam; massive parent material; very friable when moist; violent effervescence

NOTE: Colors given for moist soil

Waukon Clay Loam
West Otter Tail County
Thompson farm

MOISTURE RELEASE DATA

Depth (inches)	Percent water at respective tensions in atmospheres								
	1/10	1/3	1/2	2/3	1	2	5	10	15
0-6	30.8	25.6	23.6	22.1	19.4	16.9	15.0	12.4	11.8
8-12	23.5	19.9	18.7	17.8	15.8	14.0	12.8	11.2	10.5
13-17	26.2	22.2	21.0	20.2	17.5	15.6	14.6	12.2	12.0
18-22	31.0	25.2	24.2	23.6	20.4	19.8	17.2	14.0	13.8
23-28	30.2	23.7	22.4	21.2	19.2	16.0	13.6	10.2	10.2
33-38	25.3	20.0	17.7	16.5	15.4	12.5	10.2	7.8	7.8

AVAILABLE MOISTURE AND PARTICLE
SIZE DISTRIBUTION

Depth (inches)	Bulk density	Particle size, %			Avail. in H ₂ O per inch	Avail. in. H ₂ O per horizon	Total in. H ₂ O per horizon
		Sand	Silt	Clay			
0-6	1.20	44.8	28.6	26.6	0.17	1.19	2.17
8-12	1.28	50.6	18.8	30.6	.12	.60	1.25
13-17	1.42	46.4	19.9	33.7	.15	.75	1.60
18-22	1.42	41.5	19.7	38.8	.16	.80	1.80
23-28	1.42	42.1	23.3	34.6	.20	1.60	2.72
33-38	1.38	52.2	22.5	25.3	.16	4.80	8.10

Total in a 5-foot profile... 9.74 17.64

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Growth Through Agricultural Progress